Scalable Internet Servers and Load Balancing

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Internet Services and Servers

- Internet Services
  - Services accessible to online users through Internet.
- Services on the Internet
  - Online keyword search engine: Google.
  - Web email service: Hotmail.
  - News service: CNN.
  - Other portal services: Yahoo!, AOL, MSN.
- Scalability requirements
  - Many simultaneous user accesses; large amount of hosted data, ...
- Internet Servers
  - Computer systems that host Internet services.

Internet Services are at the Application Layer

- Normally on the end hosts, involving no routers
- Function on transport-layer protocols TCP/UDP

Search Engine as An Example: Step 1 - Crawling

- Crawling - get all these Web pages out there:
  - First retrieve some root pages;
  - Parse their content and follow hyperlinks to retrieve more pages;
  - Depth-first search or breadth-first search?
Performance Analysis for Crawling

- The key to make it run fast – relieve the performance bottleneck.
- What are the resources involved?
  - CPU processing for TCP/HTTP protocol handling and the parsing of page content
  - local disk bandwidth
  - network bandwidth to remote web sites
- Assume average page size 10KB
  - raw processing power of a single CPU
    - one thousand fetches/second ⇒ around 10MB/s
  - I/O bandwidth of a single disk
    - up to 30MB/s (disk write)
  - network bandwidth from/to the Internet
    - T1 link (1.5Mbit/s); T3 (45Mbit/s)

Search Engine as An Example:
Step 2 - Indexing

- Indexing
  - crawled raw web pages are not easy to search.
  - we index them to formats that are easy to search.
- As part of indexing, we need to give each page an ID
  - using a hash function.

Computer: Page #123 Page #357 ... ...
Networks: Page #124 Page #468 ... ...

Search Engine as An Example:
Step 3 - Online Search

Partitioning and Replication

Index servers
Page servers
Web server/Query handler
Firewall
Local-area network
Internet
Index servers
Page servers
Web server/Query handler
Firewall/Switch
Local-area network
Internet
Scalability, reliability
Load Balancing over Internet Servers

- Popular sites like Google or CNN receive tens or hundreds of millions of hits per day.
- A large number of replicated servers are used at these sites.
- **Key question:** how to balance client requests over these servers?

Discussions on DNS Rotation

- **Advantages**
  - Require almost no change on the existing Internet architecture

- **Problems**
  - DNS Caching
  - Rigid load balancing policy
    - can’t balance based on runtime load changes
    - slow or no adjustment in response to failures

Load Balancing on Internet Servers

**Technique 1 - DNS Rotation**

1. Web servers for CNN.com
2. Firewall/Internet
3. DNS server for CNN.com
4. IP address of CNN.com

**Advantages**

- Require almost no change on the existing Internet architecture

**Problems**

- DNS Caching
- Rigid load balancing policy
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**Technique 2 - Cooperative Offloading**

1. Web servers for CNN.com
2. Firewall/Internet
3. DNS server for CNN.com
4. IP address of CNN.com
Discussions on Cooperative Offloading

- Can be combined with the DNS rotation.
- Advantages:
  - More flexible policy is possible
  - Be more responsive to runtime workload and server failures (to a certain degree)
- Problems
  - Need a lot more software
  - Longer delay

Cooperative Offloading with TCP Handoff [Pai et al. ASPLOS1998]

Load Balancing on Internet Servers
Technique 3 – Load Balancing Switch

- More About Load Balancing Switch
  - How deep do we need to look into the network protocol stack?
    - Network layer (IP)?
    - Transport layer (TCP/UDP)?
    - Application layer?
  - Load balancing policies in LB switches (Goal: transparency, plug-and-play)
    - Simple rotation
    - Least number of active requests
    - Shortest response time
Summary

- Scalable Internet servers
  - partitioning
  - replication

- Load balancing on Internet servers
  - DNS rotation
  - cooperative offloading (w. TCP handoff)
  - LB switches

- For each technique, changes required on the components:
  - DNS server??
  - Web server??
  - client??
  - switch??